Birck Nanotechnology Center Discussion Forum on Future Centers of Excellence

Summary of Meetings
December 16-17, 2020

January 9th, 2021

Ali Shakouri
Zhihong Chen

Looking Ahead: Ten Big Ideas

Navigating the New Arctic

Harnessing Data for 21st Century Science and Engineering

Work at the Human-Technology Frontier: Shaping the Future

RESEARCH IDEAS

Understanding the Rules of Life: Predicting Phenotype

The Quantum Leap: Leading the Next Quantum Revolution

Windows on the Universe: The Era of Multi-messenger Astrophysics

PROCESS IDEAS

Growing Convergent Research at NSF

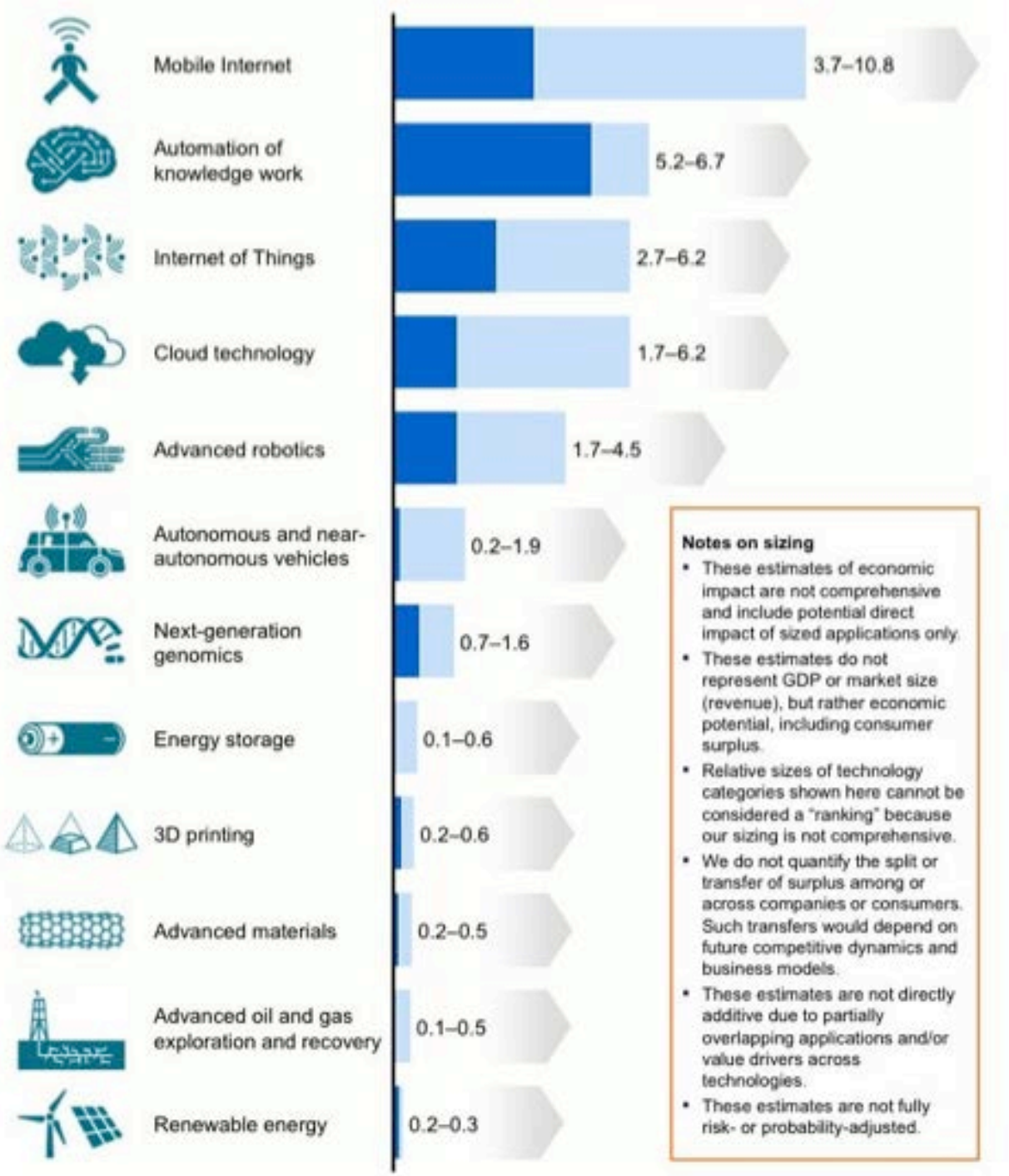
NSF-Includes: Enhancing Science and Engineering through Diversity

Mid-scale Research Infrastructure

NSF 2050: Seeding Innovation

Business Trends ($T)

McKensie
(2014)



Grand Challenges

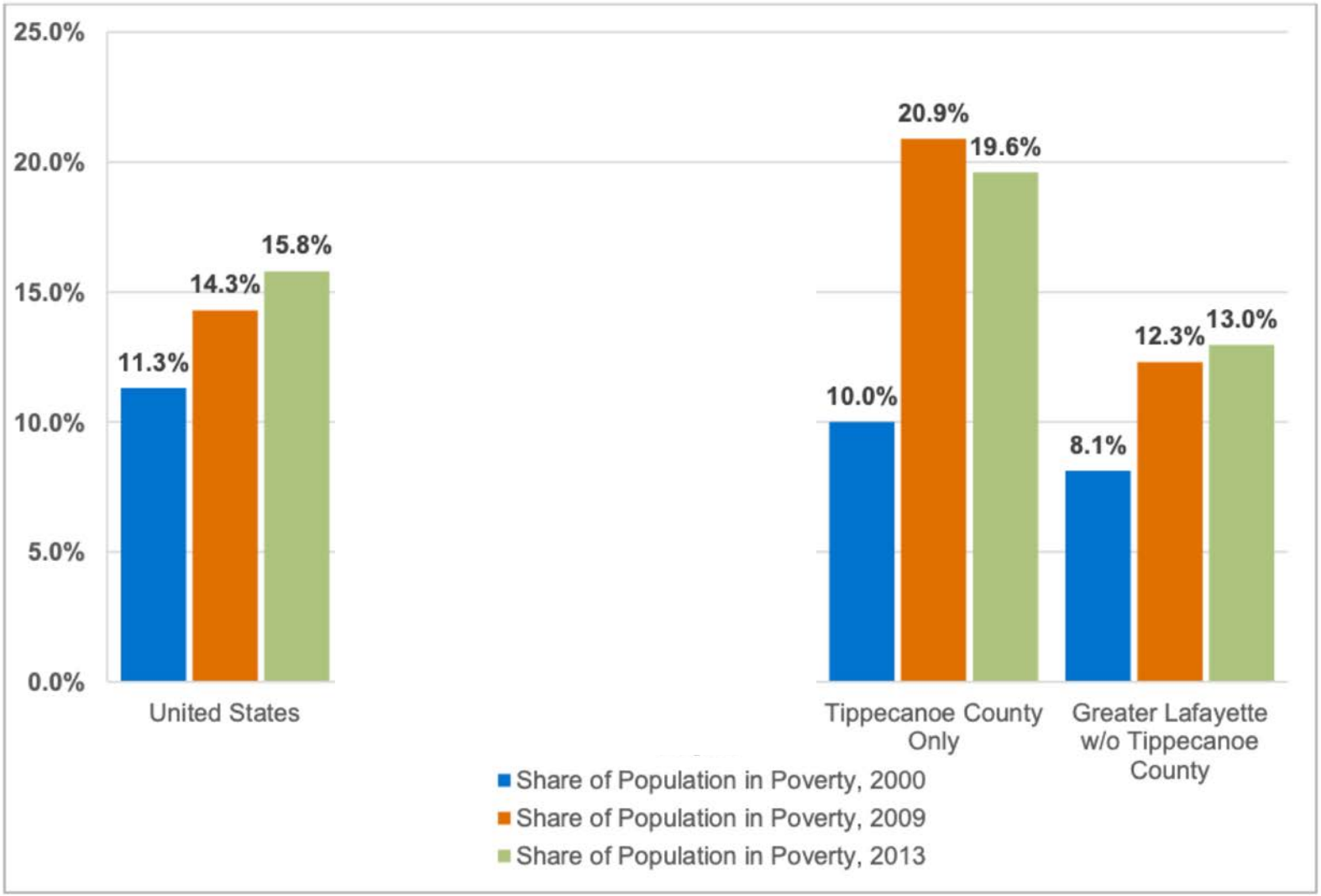
Global Megatrends (Discovery Park)

PURDUE UNIVERSITY Discovery Park

US vs. Local Trends

PURDUE UNIVERSITY Discovery Park

Figure 12. Share of Population Considered to be in Poverty



Source: U.S. Census, Small Area Income and Poverty Estimates (SAIPE), 2000, 2009, and 2013 (most recent available).

Population Trends in the Region, 2000-2018

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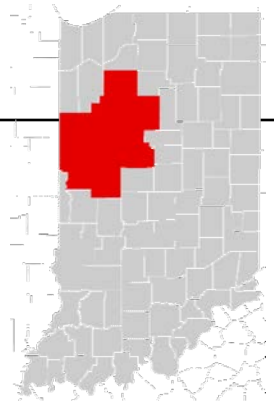


Regional Engagement: Wabash Heartland Innovation Network (WHIN): 2018-2022, $38.9M

Birck Center, Ag, Engineering, Krannert and Polytechnic

(IoT sensors/data analytics, digital ag and next generation manufacturing)

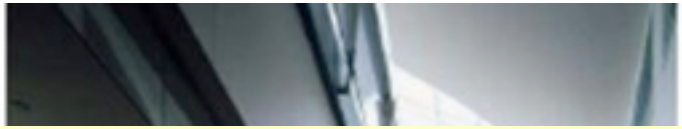
https://www.purdue.edu/whin/

BNC Concept

PURDUE UNIVERSITY Discovery Park

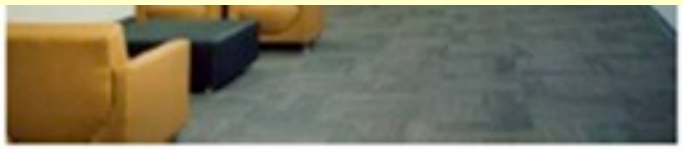
Engaging interdisciplinary, Societal-scale challenges and opportunities in healthcare, information access, energy, and the environment with approaches enabled by the latest science and engineering (nano, quantum, IoT, …)

- Community encompassing a very broad span of disciplines in the same space
- Best facility and tools
- Fluid…no "ownership" of space
- Sustainable financial model



2007 Facility of the Year Award by Controlled Environments Magazine

Assisting the design of nano centers at MIT, Princeton, Stanford, UC Berkeley, Gatech, Penn State, Argonne as well as international centers at Mexico, Colombia, India, Kuwait and Qatar



Tim Sands 2009

BNC Resident Faculty & Main Research Thrusts

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Research Thrusts		Resident Faculty
Electronics	6	Alam, Appenzeller, Z. Chen, Janes, Morisette, Ye
Photonics	9	Alaeian, Bermel, Boltasseva, Hosseini, Hung, Jacob, Kildishev, Narimanov, Shalaev
MEMS/ Microsystem	4	Bhave, Mohammadi, Peroulis, Weinstein
Cond. Matter Physics	5	Y. Chen, Ma, Malis, Manfra, Rohkinson
Thermal/ Packaging	8	Marconnet, L. Pan, Ruan, Shakouri, Warsinger, Weibel, Xu, Yazawa
R2R/ Manufacturing	7	Cakmak, Chiu, Mei, Rahimi, Stanciu, Wei, Ziaie
Nanobio/ Soft Materials/ LyoHUB	12	Cappelleri, Garner, Han, Lelievre, Mcnally, Panigrahi, Savran, Suter, Verma, Wereley, Alexeenko, Topp
Material Growth/ Char.	3	Capano, Marinero, Na, H. Wang, F. Ribeiro
AFM/ Surface	4	Raman, Reifenberger, Rhoads, Wagner

Resident Faculty 58: ECE 21, ME 14, Physics 7, MSE 5, Other Engineering 5, Other Science 2, Polytechnic 2, Pharmacy 1, Vet Med 1 + **Non-Resident Faculty:** ~70 (35 departments)

Students: 220 resident + 300 other users

Industry: Nanovis, Microsoft Station Q, LyoHUB (25 companies), SMART (5 companies)

All Equipment/Tools: BNC Wiki https://wiki.itap.purdue.edu/display/BNCWiki

Birck Directors and Research Staff

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Director	Ali Shakouri
Associate Director for Research	Zhihong Chen
Associate Director for Operation	Sunil Bhave
Research Manager	Tracy Hudson
Electron Microscopy	Rosa Diaz
Surface Science	Dima Zelmyanov
Optics	Alexei Lagoutchev
Processing, Electrical Characterization	Nithin Raghunathan
Biolabs/ 3D Cell Culture	Yunfeng Bai
Spintronics	Neil Dilley
PQSEI Managing Director	David Stewart
R2R Manufacturing	Nick Glassmaker
R2R In-line Characterization	Ye Mi
WHIN Managing Director	Ted Fiock
WHIN IoT Testbeds	Harris Mousoulis

Centers of Excellence based on Birck Annex Discussions (Aug. 2019-June 2020)

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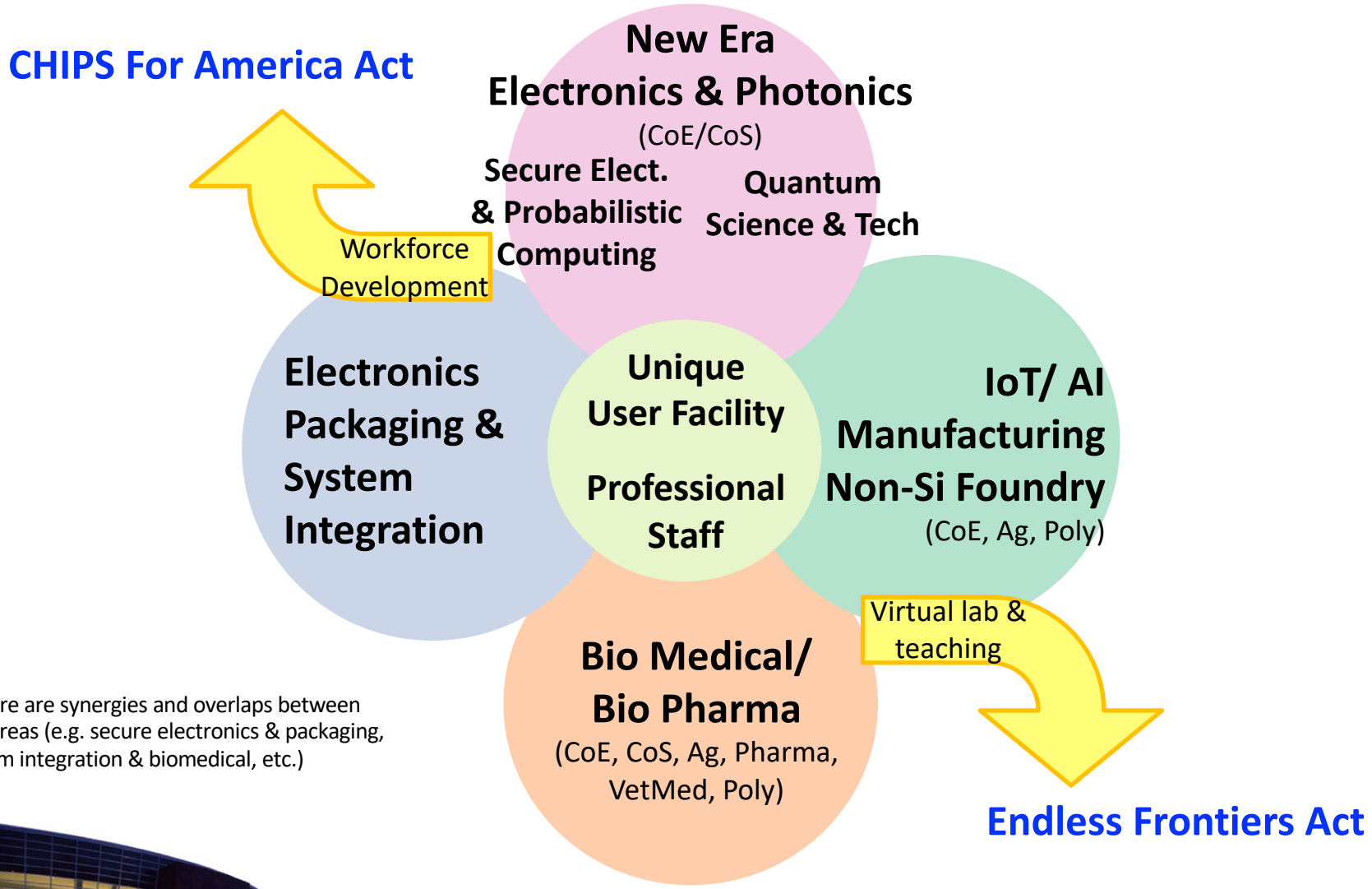

* There are synergies and overlaps between sub-areas (e.g. secure electronics & packaging, system integration & biomedical, etc.)

(1) Biomedical/Engineering

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Core Group: Rams Ramaswami, Chris Rochet, Bumsoo Hun, David Cappelleri, Babak Ziaie, Lia Stanciu, Alex Wei, Chi-Hwan Lee, Krishna Jayant, Rahim Rahimi, others?

Grand Challenges:

- Molecular processes inside living cells
- Microbiome
- Large area artificial skin
- Emergency response (point-of-care)

CoE, CoS, Ag, Pharma, VetMed, Poly

Technology:

- Frontiers of biological imaging
- Organoids/ Lab on a chip
- Digital human
- Micro soft-robotics inside the body
- Ubiquitous low-cost IoT devices
- Measurement science/ Analyt. Chem.

Endless Frontiers Act

Virtual lab & teaching

Eli Lilly, Elanco, Roche, Industry Consortia, DoD and National Lab partnerships

PIIN, PI4D
Bindley
LyoHUB

(2) Ag/Food Systems

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Core Group: Tim Filley, Ajay Malshe, Rahim Rahimi, Travis Horton, David Warsinger, Carson Reeling, others?

Grand Challenges:
- Sustainability, food insecurity
- Carbon economy; nexus of energy, water and food

Ag, CoE, VetMed, Polytechnic

Technology:
- Ubiquitous low-cost IoT devices
- AI at the intersection of Cyber and Physical. Machine learning + physics models. ML extrapolating beyond training sets
- Modeling (ecosystem and socio-economic impact)

Manufacturing USA

Regional Ecosystem (WHIN, DP District)

SMART, C4E, Plant Science Initiative

(3) Computing and Communications
(electronics, photonics, 3D heterogenous integration)

PURDUE UNIVERSITY Discovery Park

Core Group: Zhihong Chen, Joerg Appenzeller, Peide Ye, Gerhard Klimeck, Yong Chen, Peter Bermel, Sunil Bhave, Vlad Shalaev, Zubin Jacob, Chen-Lung Hung, Justin Weibel, Haiyan Wang, Xinghang Zhang, Shriram Ramanathan, Wenzhou Wu, Letian Dou, others?

Grand Challenges:
- 5G and beyond
- Secure electronics
- Others?

CoE, CoS

Technology:
- Hybrid Quantum and AI technologies
- Electronics packaging and 3D heterogeneous system integration
- Probabilistic computing
- Quantum electrodynamics and metrology
- Hybrid photonics and superconducting electronics

CHIPS For America Act

Workforce Development

PQSEI
nanoHUB
PINE
iGSDI

Microsoft, SRC, TSMC, LM, Intel, Samsung, Crane, Draper, Sandia, Oak Ridge

National Initiatives in Quantum, AI and Trusted Electronics

(4) Manufacturing

PURDUE UNIVERSITY Discovery Park

Core Group: Miko Cakmak, Jan-Anders Mansson, Jan Allebach, Jianguo Mei, Ashraf Alam, Bruno Ribeiro, Xianfan Xu, Xinghang Zhang, John Sutherland, Ali Shakouri, others?

Grand Challenges:

- Distributed scalable and secure manufacturing
- Sustainable manufacturing (minimum energy/ water use, recycling)
- Training of future workforce

CoE, Polytechnic, Krannert

Technology:

- AI at the intersection of Cyber and Physical. Machine learning + physics models. ML extrapolating beyond training sets
- AI Human/Machine interface
- Technical cost modeling
- 3D nano manufacturing
- Develop a foundry for non-silicon IoT devices near Purdue (roll-to-roll manufacturing)

Manufacturing USA

Regional Ecosystem (WHIN)

SMART
IMI
IN-MaC

(A) Local Community Engagement

PURDUE UNIVERSITY Discovery Park

Core Group: Ali Shakouri, Ted Fiock, Karthik Kannan, Ajay Malshe, Purdue-WHIN Team, Others?

Leverage WHIN project, expand beyond ag and manufacturing

- Privacy-preserving regional AI network for scalable and secure manufacturing
- AI for healthcare, future of insurance
- AI for workforce training, eLearning, future of work
- Smart roads/ infrastructure; Leverage DP District

LEI's WHIN Project

(B) Interdisciplinary Collaborations, Increase Purdue visibility

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Core Group: Sorin Matei, Neil Dilley, Sasha Boltasseva, Others?

Increase visibility of Purdue research nationally or internationally

- Collaboration with **Brian Lamb School**, **Art & Design** (e.g. storytelling course modules, future thematic Purdue 2050 Conferences, …)
- Develop “demonstrators" highlighting Purdue’s "first-best-only” (ideas by Sorin Matei and Dimitri Peroulis)

Funding

Major center proposals are great opportunities to put together interdisciplinary teams, but we need to start working 2-3 years in advance. We should be better prepared for new programs (e.g. NSF AI Institutes, Mid-Scale Instrumentation), but we should also leverage non-traditional funding sources

- Foundations, philanthropic
- Industry consortia
- Leverage contacts through Lewis-Burke, IEDC, etc.
- Partnerships with Lilly, Elanco, Roche, Rolls-Royce, GE or other local companies

Potential Grant Timeline (2021 and beyond)

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Q1 — Jan, Feb, March 2021

JAN January

Collaborative Approaches to Engineer Biology for Cancer Applications - Deadline Jan 15

Synthetic Biology for Biomedical Applications - multiple deadlines starting in Jan (see notes)

Secure and Trustworthy Cyber-Space - Large Grants Due - Last week Jan 2022 (est): Small and Medium grants - Due Anytime in 2021

FEB February

Mid-Scale Research 2 LOI - Feb 3; Preproposal March 5; Full Proposal Sept 20 - $20M - $100M for up to 5 years

ERC Planning Grant Due Feb. 16

Chan Zuckerberg Initiative - Visual Proteomics Imaging - 2.5 year challenge grant - Feb. 17

Growing Convergence Research - Deadline - Feb. 1, 2021 - First Monday in Feb thereafter

Smart Farming Innovations for Small-Scale Producers - Gates Foundation Global Grand Challenges - Due Feb. 25

Q2 — April, May, June 2021

APR April

MAY May

3D Human Biomimetics for Infectious Diseases (U19) - 2021 RFA Pending - Due Approx. May 6 - NIAID intends to commit $4.5 million in FY 2021 to fund 2-4 awards

JUN June

MURI - 2021 RFA Pending - White papers due in June (estimated); Applications due in Sept (estimated). Typical annual funding per grant is in the $1.25M to $1.5M range

March

NIH U54 - Cellular Cancer Biology Imaging Research Program - Due March 18

Industry-University Cooperative Research Center - Preliminary Proposal - Second Wed in March

Future of Work at the Human-Technology Frontier - Deadline - March 23, 2021

Check status of CHIPS for America

Check on Endless Frontiers Act

Q3 — July, Aug, Sept 2021

JUL July

AUG August

Physics Frontier Center - 2021 RFA Pending - Prelim Proposal - Aug; Full Proposal Jan - est; Estimated Number of Awards: 3 to 5 Anticipated Funding Amount: $5,000,000 to $8,000,000

SEP September

Industry-University Cooperative Research Center - Prelim Proposal - Due Second Wed in Sept.

Q4 — Oct, Nov, Dec 2021

OCT October

NOV November

DEC December

National AI Research Institutes - 2021 RFA Pending - This solicitation will support cooperative agreements of between $16,000,000 and $20,000,000 for between four and five years ($4,000,000 per year on average).

Trans-Agency Blood-Brain Interface Program (R61/R33) - est - 2021 RFA pending - check on September 2021 announcement / December deadline est

CISE Community Research Infrastructure - LOI - Dec. 14, 2021; Full Proposal - Jan. 28, 2022

2022

DMREF - Jan. 25 deadline

ERC - RFA Pending - Preproposal est. for Oct. 2022

STC - RFA Pending - Est. June 2022 preproposal deadline

MRSEC - RFA Pending - Est June 2022 preproposal.

2023

Mid-Scale Research-1 - RFA Pending January (est)

Purdue 2050: Conference of the Future

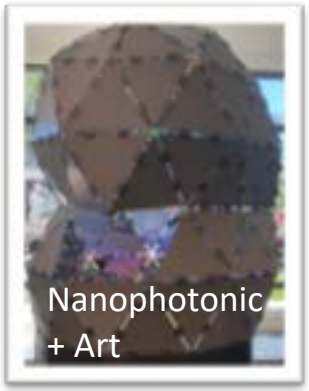
September 26-27, 2019, Honors College

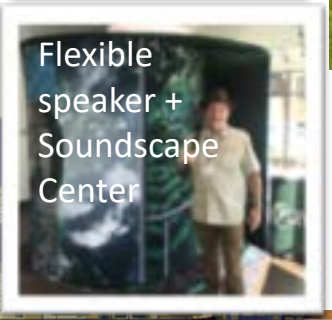
Link to talks: https://www.purdue.edu/discoverypark/2050/

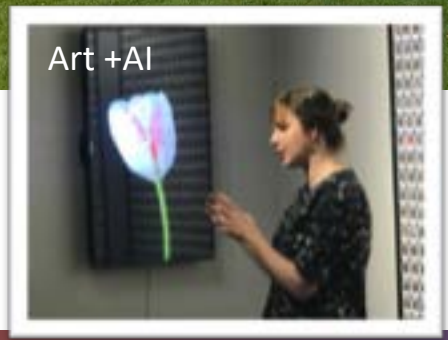
Purdue 2050
Conference of the Future

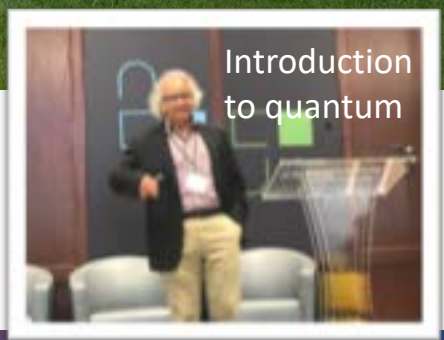

Real-time video analytics during workshop

Collaboration with Honors College, College of Liberal Arts, Krannert Business Analytics, The Data Mine, Regenstreif Center
=> Future thematic workshops/conferences with unique exhibition (demonstrators) to increase Purdue's visibility


Nanophotonic + Art


Flexible speaker + Soundscape Center


Art +AI


Introduction to quantum

Leverage WHIN and DP District

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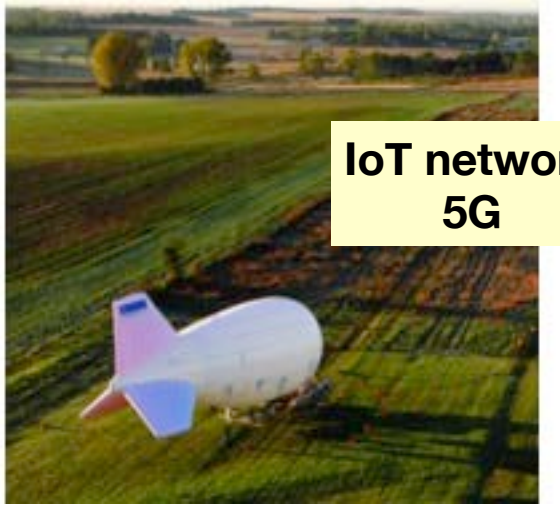
Real-time sensors and living labs (Birck, IMI, Manufacturers) used to teach <u>data science, AI, system of systems</u>

- **Example: NSF I-USE: Polytech/ Birck:** B. Newell, K. Yazawa, A. Magana, A. Shakouri Circuits, Fluid Power and Applied Thermodynamics
- **Other courses that can leverage living labs?**



Example: Potential Collaboration DPD/ WHIN RTO Wireless Aerostat

Convergence Building

CARR
WORKPLACES
CONVERGENCE

PURDUE'S NEWEST HOME FOR INNOVATION, COLLABORATION, AND PRODUCTIVITY

Whether you need short term space for an ad hoc meeting or more long term space in the form of a private office, Carr Workplaces Convergence offers a variety of workspace options.

PRIVATE OFFICES

VIRTUAL OFFICES

COWORKING

TEAM ROOMS

MEETING ROOMS

EVENT SPACE

(765) 300-4974 | carrworkplaces.com/convergence
101 Foundry Drive, Suite 1200 West Lafayette, IN 47906

Industry collaborators on campus

Strategic Action Plan –faculty leads?

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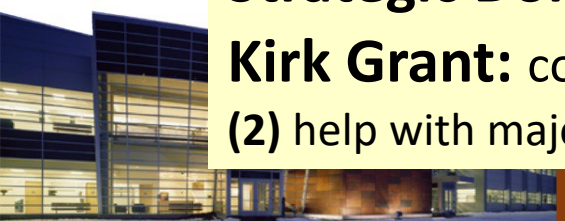
1. Helping Multi-disciplinary Teams Excel (strategic agenda)
   - Strengthen PI network –Journal club, BNC seminars, co-teach classes, unexpected interactions/ lunches
   - Develop mentoring networks –Seek advice from faculty with experience in small and large centers (MURI, EFRC, STC, ERC,…)
   - Communicating Birck stories -Storytelling competition, workshop/ EdX/ nanoHUB short courses, Purdue 2050 Conference
2. Develop New Centers
   - Scouting for weak signals -Fed. budget allocations, i.e. Lewis-Burke
   - Program manager interaction
   - Multi-PI and center proposal opportunities
3. Help Create a Local High Tech Ecosystem
   - Community IoT Testbeds WHIN; DP District Living Lab.

Strategic Doing Framework: persistence, regular follow up

Kirk Grant: consultants to **(1)** help teams with Strategic Doing, **(2)** help with major grants supporting strategic research directions



How Can Purdue Compete with Other Centers of Excellence?

Competition: SMART films & R2R manufacturing

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Top Universities/groups in SMART films /low-cost IoT devices

- Stanford, Berkeley, MIT, UC San Diego

Top Centers in R2R manufacturing:

- Umass Amherst ($25M): Strength in polymers & nano-materials
- Univ. of Washington ($30M): focused on solar cells and batteries (energy applications)
- NextFlex ($75M): Hybrid IC chip integration (short term, complementary)
- Holst Center/IMEC ($150M): focused on IP generation, existing tools/ fab in Asia

How Purdue will position itself?

(1) Full vertical integration (from materials & manufacturing to IoT systems and data analytics), applications to sustainable ag/food, healthcare, emergency response, infrastructure
(2) Foundry for non-silicon IoT devices.
(3) AI/machine learning applied to privacy-preserving resilient and distributed manufacturing
(4) Regional IoT testbeds in ag and manufacturing ($38.9M WHIN project)

Competition: Biomedical / Biopharma Facility

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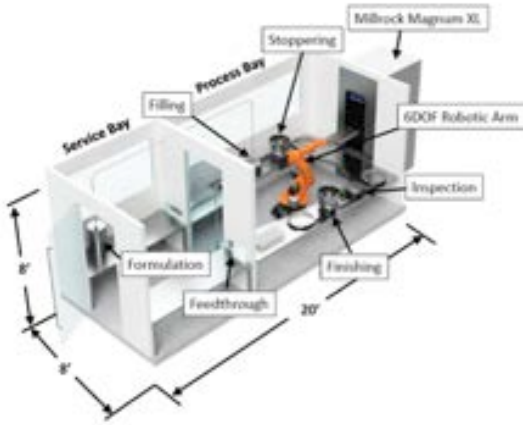
Top Centers in Biomedical /Pharma manuf. and how Purdue will position itself:

- Biomedical: Harvard, UCSF, Stanford, … (strong medical schools)
- Pharma: NCSU, NJIT, Rutgers (strong pharma programs, engineering not at the level as Purdue)

There are very strong biomedical facilities in major universities with top Medical Schools. Purdue has a highly ranked Vet School. Purdue's investment in Health Sciences can leverage Birck by:

(1) Strengthening the connection with CoE (ECE, ME, MSE, microfabrication, heterogenous system integration and packaging), CoS (Measurement Science)
(2) Basic biological science studies using organoids on a chip and microfluidics
(3) Pharma manufacturing (collaboration Engineering/ Pharmacy), FDA training

Purdue is also uniquely positioned to take advantage of the major shared resources in Indiana, with strong on-going collaborations with biomedical industry: Lilly, Elanco, Roche, etc.



Competition: Quantum Science & Technology

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Top Centers in Quantum and how Purdue will position itself:

Multiple new quantum centers in US, extremely sophisticated in their lab space. e.g.

- U Chicago (Awschalom led, constantly expanding very aggressively, esp. photonics)
- Caltech (Amazon is starting a new building there)
- Harvard (internal funding of over $5M for quantum)
- Maryland (Joint Quantum Institute, esp. in AMO physics)
- Colorado (JILA Center with NIST -- AMO physics, recent expansion in engineering)
- UIUC (IQUIST center, >$10M funding)
- UCSB (site of Microsoft station Q and NSF quantum materials foundry)
- Berkeley (strength in superconductor quantum computing etc.)
- Yale Quantum Institute (strength in superconductor quantum computing etc.)
- Pittsburgh Quantum Institute
- U Penn (combining Physics + ECE)
- Colombia Quantum Initiative

PQSEI has strong faculty in quantum materials/devices (esp. based on semiconductors or topological/2D materials, building on strengths in condensed matter physics in PHYS and microelectronics/nanotech in ECE) and quantum photonics (esp. ultrafast quantum photonics, quantum plasmonics, with strengths in AMO physics in PHYS and field/optics in ECE), well positioned to develop unique and novel hybrid quantum systems (e.g. interfacing ultrafast quantum photonics with electronic-spintronic systems) and quantum sensing technologies (with broad applications)

Competition: Packaging/System Integration

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Top centers in packaging and systems and how Purdue will position itself:

- **GTech**: One of the largest university electronics packaging centers (SRC).
- **UIUC: L**arge interdisciplinary team with POETS Center on electro-thermal systems
- **Maryland:** CALCE Electronics Products and Systems center with industry sponsors; Test Services and Failure Analysis (TSFA) Laboratory
- **SUNY Binghamton**: Close collaboration with IBM; S3IP Center of Excellence
- **Auburn:** CAVE^3 (NSF Center): Surface Mount Assembly and Electronic Packaging facilities

Purdue has unique strengths in reliability physics, heterogeneous integration, 3D packaging, and thermal management with vibrant industry consortia: CTRC (NSF) and CHIRP (SRC). Rather than applied testing and throughput, Purdue will differentiate via high-fidelity characterization tools that offer unique abilities to extract scientific understanding, develop physical models, and determine root cause.

Competition: Secure Electronics

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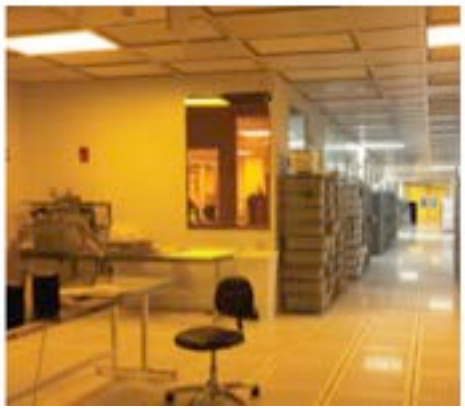
Top Centers in Secure/Trusted Electronics and how Purdue will position itself:

- **Vanderbilt** (radiation hard electronics)
- **MIT** (semiconductor electronics)
- **Berkeley** (microelectronics)
- **Stanford** (3D chip design)

Purdue has very strong microelectronics simulation and experimental research, as well as education programs with high external reputation. Given the new opportunities in microelectronics and secure electronics, Purdue is well positioned to lead both research and education in these directions.



Other Potential Centers

PURDUE UNIVERSITY Discovery Park

- **Collaboration with other Discovery Park Centers**
  (Bindley, PIIN, PI4D, C4E, iGSDI, IDSI, PPRI, nanoHUB, etc.)
- **Herrick/ Zucrow Collaboration? (DoD, DoE)**
- **…**

Multi PI and Center Proposal Opportunities

PURDUE UNIVERSITY Discovery Park

- NSF ERC, STC, MRSEC, Mid Scale Instrumentation
- NSF DMREF, CPS ($1-2M programs, 3-5 PIs)
- NSF AI Institutes (What can we do at the interface of virtual and physical?)
- DoD MURI (Topics decided by PM, initiate ideas?)
- DARPA Programs (Topics decided by PM, initiate ideas?)
- DOE EFRC (Next round topics haven't come out)
- NIH Programs
- USDA Programs

Leverage Lewis-Burke (Purdue consultants in Washington)

Major Center Proposals:

+ Brings the team together. Learn from best practices. Specific deadlines.

- Very small success rate. Couple efforts on major centers with other smaller proposals (obtain preliminary results working in small groups)

Title	Deadline	Funding No. / Amt	Summary
Planning Grants for Engineering Research Centers (ERC)	February 16, 2021	20 Funded / $2,000,000	The ERC program intends to support planning activities leading to convergent research team formation and capacity- building within the engineering community. This planning grant solicitation is designed to foster and facilitate the engineering community's thinking about how to form convergent research collaborations.
Engineering Research Center (ERC)	LOI Sept. 2023 (Estimated)	1 to 5 Funded / Approx. $26,000,000 (may be up to $130,000,000 like Gen IV)	The NSF Engineering Research Center (ERC) program supports convergent research, education, and technology translation at U.S. universities that will lead to strong societal impacts. • Need strong industry engagement (funding) • RFP every 2 years: LOI Sep. 2, Preproposal Oct. 2, 2020; Full May 07, 2021 • Next round expected: Preproposal –- 2022; Proposal – 2023
Science and Technology Centers (STC)	LOI June 2023 (Estimated) **Limit on Number of Proposals per Organization:** 3	$25M for 5 years (Approx.)	STCs conduct world-class research through partnerships among academic institutions, national laboratories, industrial organizations, and/or other public/private entities, and via international collaborations, as appropriate. • ~ $5M/year for 5 years with possibility of a 5 year continuation • RFP every three years: Preproposal – Jun. 25, 2019; Full - Jan. 27, 2020 • Next round expected: Jun., 2022

Title	Deadline	Funding No. / Amt	Summary
Materials Research Science and Engineering Centers (MRSEC)	LOI June 2022 (Estimated) **Limit on Number of Proposals per Organization:** 1	Range from $2.6 million/year for a 2-IRG MRSEC to a maximum of $4 million/year for a 3-IRG MRSEC.	The MRSECs program provides sustained support of interdisciplinary materials research and education of the highest quality while addressing fundamental problems in science and engineering. • Compete every three years: Preproposal – Jun. 24, 2019; Full proposal – Nov. 26, 2019 • Next round expected: Jun., 2022
Mid-scale Research Infrastructure-1	Prelim Proposal Jan. 2023 (Estimated)	Implementation projects - range from $6M - $20 million. Design projects - minimum request of $600,000 / max request up to but not including $20 million.	NSF defines Research Infrastructure (RI) as any combination of facilities, equipment, instrumentation, or computational hardware or software, and the necessary human capital in support of the same. Major facilities and mid-scale projects are subsets of research infrastructure. • Need Project Execution Plan • RFP every two years: Jan. 7, 2021; Proposal – Apr. 23, 2021 • Next round expected: Jan. 2023

NSF Mid-scale Research Infrastructure-2

Equipment, instrumentation, cyberinfrastructure, broadly used large-scale data sets, and the commissioning and/or personnel needed to successfully complete the project. Should fill a research community-defined scientific need, or address an identified national research priority, to be competitive in a global research environment.

Deadlines: February 3, 2021 – LOI; March 5 – Preliminary proposal, September 20 – Full proposal
$20-$100 million up to five (5) years.

Mary Nauman

Title	Deadline	Funding No. / Amt	Summary
Designing Materials to Revolutionize and Engineer our Future (DMREF)	January 11, 2021 - January 25, 2021 (annual deadline expected)	Range from $1,200,000 – $1,800,000 / duration of four years.	DMREF is the primary program by which NSF participates in the Materials Genome Initiative (MGI) for Global Competitiveness. MGI recognizes the importance of materials science and engineering to the well-being and advancement of society and aims to "deploy advanced materials at least twice as fast as possible today, at a fraction of the cost."
National Artificial Intelligence (AI) Research Institutes	December 04, 2020 **Limit on Number of Proposals per Organization:** 2	This solicitation will support cooperative agreements of between $16,000,000 and $20,000,000 for between four and five years ($4,000,000 per year on average).	The National AI Research Institutes program – a joint effort of NSF, USDA-NIFA, DHS S&T, DOT FHWA, and several industry partners – will fund Institutes comprising scientists, engineers, and educators united by a common focus on advancing the research frontiers in AI. AI Research Institutes will have as their primary focus the advancement of multidisciplinary, multi-stakeholder research on larger-scale, longer-time-horizon challenges in AI research than are supported in typical research grants.
Department of Defense Multidisciplinary Research Initiative (MURI)	• White Papers: June, 2021 (Approx) • Applications: Sept. 2021 (Approx)	Typical annual funding per grant is in the $1.25M to $1.5M range.	The MURI program supports basic research in science and engineering at U.S. institutions of higher education (hereafter referred to as "universities") that is of potential interest to DoD. The program is focused on multidisciplinary research efforts where more than one traditional discipline interacts to provide rapid advances in scientific areas of interest to the DoD.

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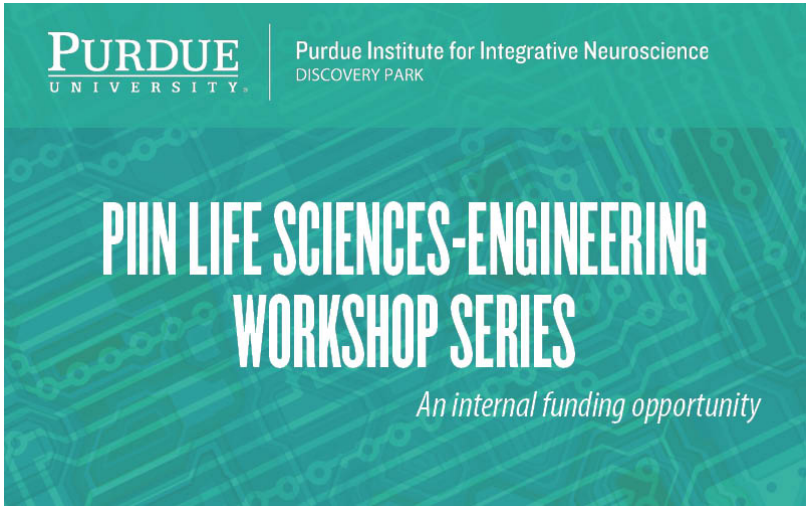
Department of Medicinal Chemistry and Molecular Pharmacology
Purdue Institute for Integrative Neuroscience

PIIN was created to bring together Purdue life scientists and engineers with interests in neuroscience.

PURDUE INSTITUTE FOR
INTEGRATIVE
NEUROSCIENCE
Where science meets engineering

The Institute is a leader at the *intersection between life sciences and engineering*, serving students and faculty at Purdue University, engaging a broad team of *collaborators throughout Indiana and the world*, and seeking to improve the human condition.

Opportunities for Collaboration between Life Sciences and Engineering



Research teams identified major problems requiring engineering solutions in:

- age-related neurodegenerative disorders
- neurotrauma
- neurodevelopmental disorders (e.g. autism)
- addiction
- hearing/communication disorders

Relevant Grant Opportunities

NIH

PAR-20-055 (R01): Engineering Next-Generation Human Nervous System Microphysiological Systems

RFA-NS-20-006 (R01): BRAIN Initiative – Biology and Biophysics of Neural Stimulation and Recording Technologies

RFA-MH-20-135: BRAIN Initiative – Tools to Facilitate High-Throughput Microconnectivity Analysis

NSF

NSF-21-532: Reproducible Cells and Organoids via Directed-Differentiation Encoding (RECODE)

NSF-21-517: Integrative Strategies for Understanding Neural and Cognitive Systems

The Chan Zuckerberg Initiative (CZI)
Visual Proteomics Imaging
2.5-year challenge grants. The ability to view protein molecules in cells and monitor changes in their structure, quantity, distribution, and interactions is key to understanding what causes diseases and finding treatments and cures. This grant program will advance technology development for the field of visual proteomics and aim to obtain near-atomic resolution readouts inside the cell.
Applications due February 17, 2021
https://chanzuckerberg.com/wp-content/uploads/2020/12/Visual-Proteomics-RFA-Announcement-and-Instructions-COMBINED.pdf

National Institutes of Health (NIH), National Cancer Institute (NCI)
Cellular Cancer Biology Imaging Research (CCBIR) Program
(U54, Clinical Trial Not Allowed)
U54 Specialized Center- Cooperative Agreements, RFA-CA-21-002
Application Due Date(s) March 18, 2021
https://grants.nih.gov/grants/guide/rfa-files/RFA-CA-21-002.html

Bumsoo Han - Synthetic biology

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(NIH) Cancer (NCI) Biomedical Imaging and Bioengineering (NIBIB)

Collaborative Approaches to Engineer Biology for Cancer Applications U01 RFA-CA-20-054

This funding opportunity announcement (FOA) invites applications to develop and apply innovative synthetic biology approaches to address challenges across the spectrum of cancer research. Projects will be required to apply a technology, based on an engineered biological system, to an important and well-defined cancer research question. Collaborative transdisciplinary teams are expected with PIs representing expertise in cancer research, engineering, and other disciplines relevant to synthetic biology.

Application Due Date(s) January 15, 2021

https://grants.nih.gov/grants/guide/rfa-files/RFA-CA-20-054.html

Notice of Special Interest (NOSI): **Synthetic Biology for Biomedical Applications**

NOT-EB-20-017

Release Date: November 24, 2020

Research Objectives

- develop tools and technologies to control and reprogram biological systems.
- apply synthetic biology approaches for the development of biomedical technologies.
- increase the fundamental understanding of synthetic biology concepts as they relate to human health.
- gain fundamental biological knowledge through the application of synthetic biology approaches.

https://grants.nih.gov/grants/guide/notice-files/NOT-EB-20-017.html?utm_campaign=+45044992&utm_content=&utm_medium=email&utm_source=govdelivery&utm_term=

Bumsoo Han -3D Engineered tissue/disease models

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Three-Dimensional (3D) Human Biomimetics for Infectious Diseases (U19) *RFA-AI-20-009*

This Funding Opportunity Announcement (FOA) will establish Human Biomimetics for Infectious Diseases Cooperative Research Centers (Biomimetics CRCs) focused on multidisciplinary research advancing and/or developing innovative *in vitro* human-cell- or -tissue-derived three-dimensional (3D) models for basic and translational research on infectious diseases.

Application Due Date(s) May 29, 2020

https://grants.nih.gov/grants/guide/rfa-files/rfa-ai-20-009.html

Trans-Agency Blood-Brain Interface Program (R61/R33) RFA-HL-20-021

Support high risk/high reward research on the blood/vascular component and regulation of the neurovascular-blood unit (a.k.a., Blood-Brain Barrier; BBB) in normal and pathological states to create enhanced/modified platforms that more closely model the human BBB. Research addressing vascular, hemostatic, hematopoietic, and/or immune cell interaction across the Blood-Brain Interface is of particular interest. This initiative will serve to stimulate the development of a new field of science and re-define the neurovascular unit to also include the blood/vascular component to develop the next generation of pre-clinical human cellular model systems of the human BBB to complement research currently based on animal models.

Application Due Date(s) December 2, 2019, December 11, 2020

https://grants.nih.gov/grants/guide/rfa-files/RFA-HL-20-021.html

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Some grant opportunities (NSF):

Physics Frontier Centers: (repeats every 3 yrs)
Preliminary Proposal: August 01, 2019, **Full Proposal**: January 30, 2020
Awards: 3 to 5, **Funding Amount:** $5,000,000 to $8,000,000
https://www.nsf.gov/pubs/2019/nsf19578/nsf19578.htm

Quantum Leap Challenge Institutes (QLCI)
Preliminary September 01, 2020 Round II QLCI proposals.
Full Proposal February 01, 2021, Round II QLCI full proposals (by invitation only).
Challenge Institute (CI): $5,000,000/year for 5 years.
https://www.nsf.gov/pubs/2019/nsf19559/nsf19559.htm

Industry-University Cooperative Research Centers Program (IUCRC)
Prelim.: March 10, 2021, Second Wednesday in March, Annually Thereafter
Prelim.: September 08, 2021, Second Wednesday in September, Annually Thereafter
$150,000 per year for Phase I
https://www.nsf.gov/pubs/2020/nsf20570/nsf20570.htm